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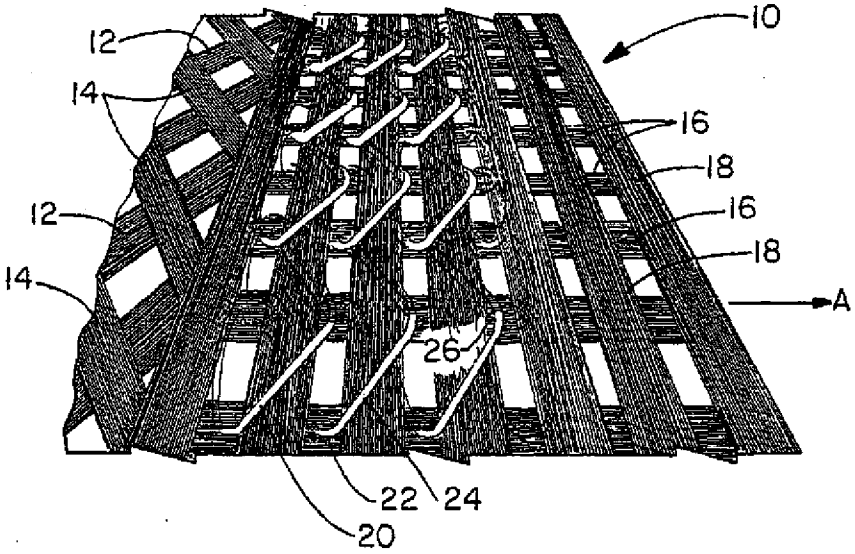
(54) Title: REINFORCING MAT HAVING THERMALLY FUSED STITCHING



(57) Abstract: A mat (10) useful for reinforcing composite materials is made up of at least first (16) and second (18) sets of fibers, the first set of fibers (16) laid as a ply in spaced apart parallel relationship in the direction of construction and the second set (18) laid as a ply in spaced apart parallel relationship perpendicular to the direction of construction. These fibers define interstices (22), into which a continuous filament (20) is knitted to provide stability. The filament (20) has a core portion (34) and a sheath portion (36), the sheath portion (36) having a lower melting point than the core portion (34). The sheath portion (36) is thermally fusible to form a plurality of closed loops in which the respective sets of fibers are entrapped. The fibers (16, 18) are glass or glass rovings and the filament (20) is a polyester, the core portion being a high-viscosity poly(ethylene terephthalate) and the sheath portion being a low-viscosity poly(ethylene terephthalate).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

REINFORCING MAT HAVING THERMALLY FUSED STITCHING

[0001] The present invention relates to a reinforcing mat, comprising either woven or non-woven fibers, wherein the fibers are held into a predetermined position relative to each other by a stitched or knitted yarn or thread. In the invention, the yarn or thread comprises at least one filament having a core portion and a sheath portion, the sheath portion surrounding the core portion along the length of the filament and being characterized by a melting point which is lower than the melting point of the core portion.

BACKGROUND OF THE ART

[0002] It is well known in many industries to manufacture reinforcing mats for use in adding strength to composite materials. Such mats are, in fact, generally referred to as composite reinforcements. These mats are then impregnated with a liquid material, such as a resin, a bitumen or the like to form a composite material.

[0003] Since it is common to prepare the composite reinforcement mats at a place and time remote from the place and time of impregnating it, it is necessary to maintain the fibers of the mats in a predetermined configuration from the point of manufacture until the point of impregnation, at which the fibers are effectively permanently oriented. In fact, it is in some cases necessary to bring more than one mat together at the point of impregnation, orient them relative to each other, and then impregnate them, locking in the relative orientation of the respective mats.

[0004] In general, the fibers used to comprise the mats have high melting points or have structural orientations internal to the fibers which could be compromised if the fibers were heated to a high enough temperature to effect any thermal bonding or fusion between the fibers. Likewise, certain adhesives which could be used to secure the fibers in the desired orientation in the mat are undesirable, because their presence adversely affects the ability of the impregnating resin or liquid to fully wet and saturate the mat at the time of impregnation. Even further, the very impregnation process works best when the reinforcing fibers are held together in only proximate relationship, but are not affixed to each other, as this allows the best penetration of the impregnating liquid.

[0005] To avoid these problems, the general prior art solution has been to fabricate a mat of the reinforcing fibers by either weaving the fibers together or orienting them into the desired relationship, and then securing them in this configuration, at least temporarily, by stitching or knitting the mat together using a filament. Just as adhesives for securing the fibers must be compatible with the ultimate impregnating agent, the filament used should also be compatible,

that is, it should be fully capable of being wetted and saturated by the impregnating agent. For this reason, some filaments which could be thermally fused after stitching or knitting are simply incompatible with the impregnating agent. An example of this would be the incompatibility of a fusible polypropylene filament with a polyester impregnant.

[0006] Stitching or knitting inherently provides relatively large loops or other closed circuits of the filament with only a small percentage of the filament sufficiently proximate to other portions of the filament to allow fusion or bonding of the filament portions.. When reinforcing mats are stitched or knitted together in the manner known in the prior art, any activity which causes breaks in the filament or pulls the filament out of place can result in catastrophic disruption of the filament matrix which the stitching or knitting has created. For example, cutting the mat, snagging the filament and the like, especially snagging the filament while painting the impregnating liquid into the mat, can all result in "unzipping" the filament, destroying the predetermined fiber orientation.

[0007] It is therefore, an unmet need of the industry to provide a reinforcing mat wherein the fibers are held securely in a predetermined orientation relative to each other prior to impregnation by a compatible filament which has been thermally fused to itself at junctures in the filament after the knitting or stitching process.

SUMMARY OF THE INVENTION

[0008] This advantage of the present invention is provided by a mat for reinforcing having a direction of construction. Such a mat has a first set of fibers laid as a ply in spaced apart parallel relationship in the direction of construction, and a second set of fibers laid as a ply in spaced apart parallel relationship perpendicular to the direction of construction. The position of the second set of fibers relative to the first set of fibers defines a plurality of interstices. A continuous filament is knitted into the interstices to provide stability to the mat, and the filament selected has a core portion and a sheath portion, the sheath portion having a melting point that is lower than a melting point of the core portion, such that sheath portion is thermally fusible to form a plurality of closed loops in which the first and second sets of fibers are entrapped.

[0009] In some embodiments, a third set of fibers is provided, laid as a ply between the first and the second sets. This third set of fibers is laid in spaced apart parallel relationship oblique to the direction of construction and oblique to the direction of the second set of fibers. Accordingly, the position of the third set of fibers relative to the first and second sets of fibers defines interstices.

[0010] In yet further embodiments, the mat comprises a fourth set of fibers, laid as a ply between said first and said second sets with the third set. This fourth set of fibers is laid in spaced apart parallel relationship oblique to the first, second and third sets, the position of the fourth set of fibers relative to the first, second and third sets of fibers further defining interstices.

[0011] In the embodiments, respective sets of fibers are glass fibers or glass rovings.

[0012] In the invention, the filament comprises a high-viscosity polyester core portion and a low-viscosity polyester sheath portion., especially a poly(ethylene terephthalate) polyester. The filament can be a mono-filament construction or a multi-filament construction.

[0013] When the third set of fibers is used, it may be laid at an angle of 45° relative to each of the first and second sets of fibers.

[0014] When the fourth set of fibers is used, it may be laid at an angle of 45° relative to each of the first and second sets of fibers and perpendicular to the third set of fibers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Better understanding of the present invention will be had when reference is made to the accompanying drawings, wherein identical reference numerals refer to identical parts and wherein:

FIGURE 1 shows a schematic partial perspective of a reinforcing mat incorporating the present invention;

FIGURE 2 shows an enlarged section of a multi-filament yarn useful in the present invention, prior to fusing of the sheath portions thereof; and

FIGURE 3 shows an enlarged section of the multi-filament yarn of Fig. 2 after fusing of the sheath portions.

DETAILED DESCRIPTION OF THE INVENTION

[0016] A reinforcing mat 10 incorporating the present invention may be fabricated in variety of manners. As one aspect of the invention is illustrated in Figure 1, the mat 10 comprises a plurality of fibers. Particularly, Fig. 1 shows four sets or plies of fibers. The third set of these fibers are indicated by reference number 12. A reinforcing mat 10 is typically constructed in a specific direction, shown in Fig. 1 as an arrow A. The fibers in first fiber set 12 are laid substantially parallel to each other and aligned at an angle of about 45° to the direction of construction A. A fourth layer or set of fibers, this one designated as 14, lie atop the third set. The fibers in fourth set 14 are also substantially parallel to each other, but they are aligned so

that their respective axes are approximately perpendicular to the axes of the third set 12. A first set of fibers 16 is laid down with the respective axes substantially parallel to the direction of manufacture A. And a second set of fibers 18 is laid atop the first set, the second set of fibers having their respective axes substantially perpendicular to the direction of manufacture A. The fibers in the respective sets 12, 14, 16 and 18 are typically lineal and will generally retain this lineality due to the inherent rigidity of the material from which they are manufactured. A commonly used fiber, for example, would be a glass fiber or a glass roving. Since the fibers in the sets 12, 14, 16 and 18 are not woven together with any of the adjacent sets and since the fibers in any given set are only laid out in approximately parallel equal spacings, the individual fibers in any given set would have no particular stability without more. Further, while the sets of fibers are shown as being laid down in the particular order shown, there is no particular benefit to the order and the fibers could be laid down in a different order relative to the other fibers and still achieve the desired result of the invention. Further, the invention requires at least two layers or sets of fibers, but the advantage of the invention may be achieved using only two layers and may also be achieved using more than the four layers specifically shown and described.

[0017] In the aspect illustrated in Fig. 1, a filament 20 is shown as being sewn or knitted into a plurality of interstices 22 between the respective fibers 12, 14, 16, 18. It will, of course, be understood that while four sets of fibers 12, 14, 16 and 18 are illustrated in Fig.1, the advantages of the present invention may be achieved through the use of a filament having a fusible sheath to lock together the stitching or knitting of the filament around at least two sets of fibers which are either interwoven or laid in non-parallel fashion, and that the invention is similarly not limited to applications involving four or fewer such sets of fibers. In similar fashion, the exact method of knitting or stitching the filament into and among the interstices provided by the fiber sets is not considered critical to the operation of the invention, and either a weft knit or warp knit, including tricot or chain, technique should prove to be equally applicable, provided that the technique provides intersection points of adjacent portions of the filament which may be fused together to define closed loops.

[0018] In the knitted condition shown in Fig.1, the filament 20 generally comprises a plurality of linear portions 24 of the individual filament and a plurality of proximate portions 26, where one portion of the filament is proximate to another portion. The present invention distinguishes the prior art at these latter portions 26. In the prior art, the proximate portions 26 of the filament are not physically joined, whether by knotting, thermal fusing or any other means. As a result, if a break occurs anywhere in the filament 20, the proximate portions 26

cannot hold the mat 10 together and the filament can be pulled free from the mat, with a loss of structure in the individual layers.

[0019] In the present invention, the mat is heated after the filament 20 has been sewed or knitted into place around the fiber sets 12, 14, 16, 18 through the interstices 22. The heating is to a temperature which is not sufficient to melt either the filament 20 or the fiber sets 12, 14, 16 and 18, but is sufficient (as explained in more detail below) to melt an outer sheath on the filament 20. Clearly, the temperature required to melt the sheath portion of the filament should be significantly less than the temperature required to cause any loss of structural properties in the fiber sets, much less to melt the fiber sets. This melting of the outer sheath portion of the filament 20 results in two possible effects. First, adjacent portions of the filament in the proximate portions 26 will fuse together, effectively forming a series of closed loops with which the fiber sets 12, 14, 16 and 18 are entrapped. Second, the same heat which fuses the proximate portions 26 is also sufficient to fuse some of the linear portions 24 to the particular fibers along which they lie. While this effect is shown and described with reference to a case where the sets of fibers are laid atop each other in a non-woven embodiment, the result would be identical if the fibers would be woven together, although the need for the present invention is not nearly so great as in the situation where the fiber sets are not woven.

[0020] A filament of the type useful in the present invention is manufactured by Kanebo Company of Japan, and commercially sold under the trademark BELLCOUPLE. The BELLCOUPLE filament, as understood from Kanebo literature, comprises at least one core portion of a high-viscosity polyester polymer and a sheath portion around the core portion comprising a lower melting point polymer, typically of a lower viscosity polyester. It is believed the Kanebo BELLCOUPLE polyester is a poly(ethylene terephthalate) ("PET"), with the cores being a high viscosity PET and the sheath being a co-polymer containing PET. The filament of the present invention construction may be presented as a monofilament construction or as a multi-filament construction. Figures 2 and 3, taken from Kanebo marketing literature, show the filament in one aspect as a multi-filament embodiment 30 in which a plurality of monofilaments 32 are massed together, each monofilament 32 comprising a core portion 34 and a sheath portion 36. In the same manner that Fig. 3 shows the respective sheath portions 36 from Fig. 2 as fusing together to form a single fused filament 38 in which a plurality of non-fused core portions 34 are embedded in a fused sheath mass 40, adjacent filaments when knitted together can fuse to form closed loops to entrap fibers in a spaced relationship as shown in Fig. 1. This is different from the use of the Kanebo BELLCOUPLE filament described in their literature, where woven filaments are fused together

[0021] A particular advantage that may be achieved with a fusible filament made of polyester is that many impregnating resins used with reinforcing mats of fiber sets as described above will be polyester resins. For that reason, the filament used to fuse the stitching in the reinforcing mats will be compatible with the resin which forms the continuous impregnating matrix surrounding and encompassing the reinforcing mat.

CLAIMS

What is claimed is:

1. A mat for reinforcing having a direction of construction, comprising:

a first set of fibers laid as a ply in spaced apart parallel relationship in the direction of construction;

a second set of fibers laid as a ply in spaced apart parallel relationship perpendicular to the direction of construction, the position of the second set of fibers adjacent to to the first set of fibers defining a plurality of interstices;

a continuous filament knitted into the interstices to provide stability;

wherein the filament has a core portion and a sheath portion, the sheath portion having a melting point that is lower than a melting point of the core portion, such that sheath portion is thermally fusible to form a plurality of closed loops in which the first and second sets of fibers are entrapped.

2. The reinforcing mat of claim 1, further comprising:

a third set of fibers, laid as a ply adjacent to said first and said second sets, the third set of fibers laid in spaced apart parallel relationship oblique to the direction of construction and oblique to the direction of the second set of fibers, the position of the third set of fibers relative to the first and second sets of fibers further defining interstices.

3. The reinforcing mat of claim 2, further comprising:

a fourth set of fibers, laid as a ply adjacent to said first and said second sets with the third set, the fourth set of fibers laid in spaced apart parallel relationship oblique to the first, second and third sets, the position of the fourth set of fibers relative to the first, second and third sets of fibers further defining interstices.

4. The reinforcing mat of claim 1, wherein the first and second sets of fibers are glass fibers.

5. The reinforcing mat of claim 1, wherein the first and second sets of fibers are glass rovings.

6. The reinforcing mat of claim, wherein the filament comprises a high-viscosity polyester core portion and a low-viscosity polyester sheath portion.

7. The reinforcing mat of claim 6, wherein the polyester is a poly(ethylene terephthalate).

8. The reinforcing mat of claim 6wherein the filament is a mono-filament construction.

9. The reinforcing mat of claim 6, wherein the filament is a multi-filament construction.

10. The reinforcing mat of claim 2 wherein the third set of fibers is laid at an angle of 45° relative to each of the first and second sets of fibers.

11. The reinforcing mat of claim 3 wherein the fourth set of fibers is laid at an angle of 45° relative to each of the first and second sets of fibers and is laid perpendicular to the third set of fibers.

12. A mat for reinforcing having a direction of construction, comprising:

a first set of fibers laid as a ply in spaced apart parallel relationship in the direction of construction;

a second set of fibers laid as a ply in spaced apart parallel relationship perpendicular to the direction of construction, the position of the second set of fibers adjacent to the first set of fibers defining a plurality of interstices;

a third set of fibers, laid as a ply adjacent to said first and said second sets, the third set of fibers laid in spaced apart parallel relationship oblique to the direction of construction and oblique to the direction of the second set of fibers, the position of the third set of fibers relative to the first and second sets of fibers further defining interstices.

a fourth set of fibers, laid as a ply adjacent to said first and said second sets with the third set, the fourth set of fibers laid in spaced apart parallel relationship oblique to the first, second and third sets, the position of the fourth set of fibers relative to the first, second and third sets of fibers further defining interstices.

a continuous filament knitted into the interstices to provide stability;

the filament having a core portion and a sheath portion, the sheath portion having a melting point that is lower than a melting point of the core portion, such that sheath portion is

thermally fusible to form a plurality of closed loops in which the respective sets of fibers are entrapped;

the third set of fibers being laid at an angle of 45° relative to each of the first and second sets of fibers;

the fourth set of fibers being laid at an angle of 45° relative to each of the first and second sets of fibers and is laid perpendicular to the third set of fibers;

the respective sets of fibers comprising glass; and

the filament comprising a high-viscosity poly(ethylene terephthalate) core portion and a low-viscosity poly(ethylene terephthalate) sheath portion.

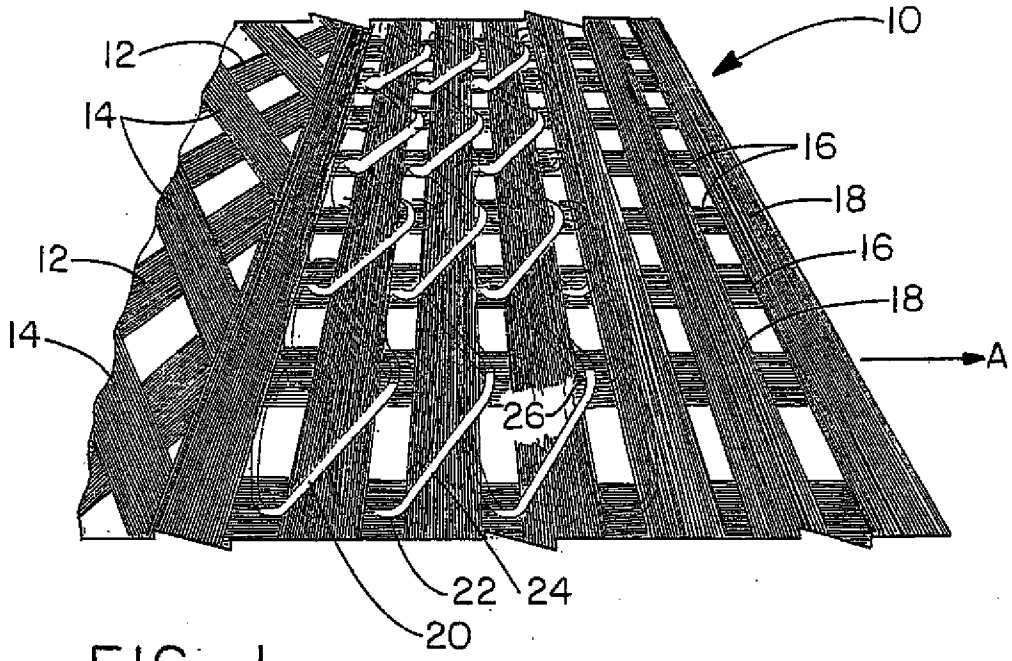
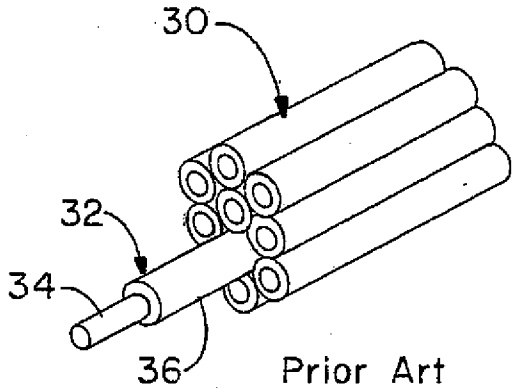
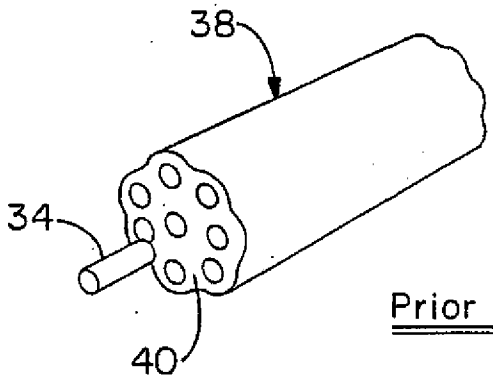


FIG.-1



Prior Art

FIG.-2



Prior Art

FIG.-3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/21508

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,902,757 A (STERN et al.) 11 MAY 1999, see entire document.	1-12N
Y	US 5,753,338 A (JELIC et al.) 19 MAY 1998, see entire document.	1-12
Y	US 5,612,114 A (ZALEWSKI et al.) 18 MARCH 1997, see entire document.	1-12
Y	US 5,203,186 A (ZAFIROGLU) 20 APRIL 1993, see entire document.	1-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

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Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MS. ARTI SINGH DEBORAH THOMAS PARALEGAL SPECIALIST Telephone No. 703-305-0661

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER:
IPC (7):

D 08 D 39/20,11/00,13/00,15/00;
B 32 B 3/06,9/00,5/12,7/00,7/08,15/00,17/02,21/02,21/10,
D 04B 1/18,11/12,21/14,7/16;
D 04 H 1/00,13/00;
D 02 G 3/00;

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

139/46,48;
428/34.5,101,102,105,119,193,222,223,293.4,293.7,295.4,299.4,371,373,397;
442/200,205,206,207,234,266,269,305,311,313,361,364,366,367.

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

139/46,48;
428/34.5,101,102,105,119,193,222,223,293.4,293.7,295.4,299.4,371,373,397;
442/200,205,206,207,234,266,269,305,311,313,361,364,366,367.